1995

Ecological impacts of coastal aquaculture developments

Aquaculture Department, Southeast Asian Fisheries Development Center

Southeast Asian Fisheries Development Center, Aquaculture Department (1995). Ecological impacts of coastal aquaculture developments. Aqua Farm News, 13(2), 2-5.

http://hdl.handle.net/10862/2460

Ecological impacts of coastal aquaculture developments

The type and scale of any ecological change associated with coastal aquaculture development will depend on the method of aquaculture, the level of production, and the biological, chemical and physical characteristics of the coastal area. The following are general discussions of these impacts:

Enrichment

The release of soluble inorganic nutrients (nitrogen and phosphorus) from intensive fish and shrimp farming has the potential to cause nutrient enrichment and eutrophication (increase in primary production) of a water body. It has also been suggested that the release of dissolved organic compounds together with other components of the diet such as vitamins could influence the growth or toxicity of particular species of phytoplankton. There are examples of eutrophication of lacustrine waters as a result of fish farming, but few examples from coastal waters. At the present level of coastal fish farming, nutrient enrichment and eutrophication of open coastal water is unlikely, but could occur in semi-enclosed coastal embayments (fjords, inlets and lagoons) which have restricted exchange of water with more open coastal waters. One example of an increase in phytoplankton biomass attributed to nutrient enrichment by fish farming is from a sheltered archipelago in Finland. Increasing eutrophication can lead to ecologically undesirable consequences and there is the possibility that waste released from fish farms could stimulate the growth of species harmful to farm stock. During the last decade, there have been many instances of mass mortality of farmed fish caused by the occurrence of harmful algae. There is, however, no evidence that the occurrence of these harmful events was due to the release of waste-compounds from the fish farms.

The increase in dissolved nutrients can be estimated using a simple mass balance approach and relating the output of nutrients to the volume and flushing time (dilution rate) of the water body. This is, however, regarded as only an approximate. It is assumed to be a complete dispersal but actually about 50% of the water is changed. The small sea-loch left during ebb tide goes back with the flood.

The deposition of organic fish farm and bivalve waste has been shown to cause enrichment of the benthic ecosystem in the vicinity of the aquaculture operation. The changes which take place include: the formation of anoxic sediments with, in extreme cases, the release of carbon dioxide, methane and hyrogen sulphide; increased oxygen consumption by the sediment and efflux of dissolved nutrients; and changes in the community structure of the benthic macrofauna. With respect to changes in the macrofauna, the effects range from a reduction in diversity and increase in opportunistic and pollution-tolerant species to the complete absence of macrofauna. The release of hydrogen sulphide gas, with hydrogen sulphide dissolved in the water deteriorated the health of farmed fish. A high level of enrichment leading to souring of sites has been reported from a number of fish farms in several countries. It has been estimated that 30% of oyster and mussel farms in France are periodically abandoned or relocated because of the accumulation of biodeposits. These are clear examples of how production can exceed the capacity of the site to assimilate the amount of waste generated and how ecological change can limit the long-term viability of a site.

Interaction with the food web

The large scale, extensive cultivation of bivalves can interact with the marine food web in two ways. Firstly, by the removal of phytoplankton and organic detritus and, secondly, by competing with other planktonic herbivores.

It is possible that the siting of bivalve farms in coastal embayments could reduce the natural productivity of the embayment. Bivalve grown by suspended culture methods will compete with other planktonic herbivores.

The carrying capacity of a natural ecosystem is the maximum production of a species which can be maintained by naturally available food resources. This particularly applies to the production of bivalves. Carrying capacity can be assessed by evaluating historical records of bivalve culture, measuring the availability of phytoplankton biomass or undertaking more sophisticated studies of carbon flux through the food web. Furthermore, models have been formulated to predict the carrying capacity of some coastal areas, the general principles of which hold true for any coastal area.

Oxygen consumption

Aquaculture production can be limited by the availability of oxygen. An assessment of this limit for an embayment can be obtained by establishing a mass balance. That is comparing the oxygen demand of the stock to the pool of available oxygen and the rate of supply. With respect to oxygen, there have been some atttempts to model the production potential in relation to aquaculture development.

In addition to the oxygen demand by the culture species, wastes and biodeposits released by a farm have a high biochemical oxygen demand. Deposition of organic waste increases the consumption of oxygen by the sediment and can result in oxygen depletion of the bottom water. A reduction in the concentration of dissolved oxygen in water passing through cage farms has also been reported.

In low energy coastal environments such as the deep basins of some fjords and inlets, the retention of deep water within the basin for a period of time results in a natural depletion of oxygen. The deposition of wastes would increase the oxygen deficit. This potential problem has been recognized in several countries. In Norway, only a low level of aquaculture production is allowed in fjord with deep isolated basins and this is restricted to the shallow, relatively well flushed nearshore areas.

Disturbance of wildlife and habitat destruction

All forms of aquaculture have the potential to affect wildlife. Human activity can be disruptive in the vicinity of important breeding colonies and feeding grounds, while the aquaculture facility itself can attract predatory species. In Germany, cormorant populations have increased as a result of poor farming. However, there have been few detailed studies on the ecological effects of aquaculture operations on wildlife.

There are reports on the impact of some forms of aquaculture on wildlife habitat. In the Philippines, 200,000 hectares of mangrove have been destroyed and in Thailand an estimated 25% of the mangrove resource has been lost as a result of aquaculture development.

Coastal wetlands are among the most productive ecosystems and are important in sustaining the ecological integrity and productivity of adjacent coastal waters. Mangrove areas are important nursery grounds for many commercial fish and shrimp species.

Interaction between escaped farmed stock and wild species

The rapid development of marine cage farming of salmonids in Europe has raised concerns about the impact of escaped fish on natural populations. It has been suggested that farmed fish have been selected for traits which make them suitable for farming but less well adapted to the natural ecosystem. Thus, escaped fish could not inititally compete with native stocks, but then decline, or the progeny resulting from interbreeding could be poorly adapted to the ecosystem.

There is insufficient information available to judge whether this interaction has a serious ecological impact. It is known that farmed fish do escape and that the numbers of escapees can be of large quantities. Some countries have initiated studies to address this issue and in recognition of the potential problem, Norway prohibits the siting of salmon farms within 30 km of important salmon rivers.

Introduction and transfers

A number of fish, invertebrate and seaweed species, have been transferred or introduced from one region to another for aquaculture purposes. A distinction has been made between the two kinds of movements which differ in their purpose and potential effect.

Transfer take place within the present geographical range of a species and are intended to support stressed populations, enhance genetic characteristics or re-establish a species and are intended to insert totally new taxa into the flora and fauna.

The problems associated with transfers and introductions have been well studied and recorded. Transfers and introductions may alter or impoverish the biodiversity of the receiving eco-

next page

system through interbreeding, creation, competition for food and space, and habitat destruction.

Examples of the type of disease problem which have arisen in the past from such movement are illustrated by the transfer of salmon smolts from Sweden to Norway and Finland, the introduction of infected ova of coho salmon (*Oncorhynchus kisutch*) from the USA and the introduction of Japanese oysters (*Crassostrea gigas*) to France .

Bioactive compounds (including pesticides and antibiotics)

Bioactive compounds should be considered as part of overall disease control strategies. However, it is accepted that many bioactive compounds, including pesticides and antibiotics, are used extensively in coastal aquaculture as the sole means of disease or pest control. Indeed, the success or failure of aquaculture may in certain circumstances depend on the timely use of such bioactive compounds to combat infectious diseases and parasites. In general, the use of such compounds in aquaculture is haphazard often reflecting the whims of the aquaculturists or disease adviser.

Longevity of inhibitory compounds in animal tissues

There is an increasing literature indicating that bioactive compounds linger in animal tissues for greater periods than had been recognized. It was reported that the antibiotic trimethroprim remained in rainbow trout muscle for 77 days after the cessation of treatment. It is recommended that for rainbow trout maintained at a water temperature of 10°C, a withdrawal period of 60 days is necessary when using antibiotics such as oxytetracycline and potentiated sulphonamides. This period is much longer than normally practiced in aquaculture.

Discharge of inhibitory compounds in the aquatic environment

The widespread use of inhibitory compounds in aquaculture has caused fears of the potential release of the bioactive component into the aquatic environment. In the case of antibiotics, this could damage biological filters in recirculating systems. Recent published data suggest that only 20-30% of antibiotics are actually taken up by fish from medicated food; thus, approximately 70-80% reaches the environment, notably from uneaten medicated food. With oxytetracycline in seawater, it has been established that degradation proceeds rapidly. However, most oxytetracycline becomes bound to particulates, and is deposited at the bottom of (or beneath) the fish holding facilities in the case of marine cage sites. Within the sediments, oxytetracycline may remain in concentrations capable of causing antibacterial effects for 12 weeks after the cessation of treatment. Such antibiotic containing sediment affects the fauna. For example, detectable levels of oxytetracycline have been found in blue mussels (*Mytilus edulis*) which were located 80 m from a fish farm using this antibiotic.

The problem with pesticides is not very well understood. Large quantities of a diverse range of natural and synthetic chemicals, including dichlorvos, malachite green, derris root, and tea seed cake, are used in coastal aquaculture worldwide. To illustrate the extent of the problem, it has been determined that during 1989, 3488 kg of dichlorvos was used in Norwegian fish farms to control infestation by salmon lice. Evidence for some compounds such as dichlorvos, has shown that some of these chemicals have adverse environmental effects, and, therefore their use in coastal aquaculture must be carefully assessed. The fate of such compounds should be properly addressed.

Development of antibiotic resistant microbial communities

There's a problem in the development and spread of antibiotic resistance among members of the native aquatic microbial communities. It has been determined that the administration of medicated food has a dramatic effect on the microbial populations within the digestive tract of the aquatic animals.

Plasmids (=extrachromosal self-replicating elements of DNA), conferring antibiotic resistance properties, abound in fish pathogens and native aquatic bacteria, particularly those in the vicinity of fish holding facilities. Workers have provided evidence of a widespread resistance to antimicrobial compounds. It is conceivable that plasmid-mediated antibiotic resistance could be transferred to bacteria of human veterinary significance. Antibiotic resitance may indeed be transferred between related bacterial group. Fortunately, cessation of treatment appears to lead to a rapid decline in the levels of antibiotic resistance of microorganisms in the aquatic environment.

Chemicals introduced via construction material

Some construction materials release substances into the aquatic environment (e.g., heavy metals, plastic additives). Their presence is unknown to most of the farmers, although awareness is increasing. Frequently, preservatives have been intentionally used assuming that they are relatively harmless to the cultured species. These include antifoulants, of which the broad ecological effects of tributylin (TBT) is a good example. Plastics contain a wide variety of additives including stabilizers (fatty acid salts), pigments (chromates, cadmium sulphate), antioxidants (e.g. hindered phenols), UV absorbers (benzophenones), flame retardants (organophosphates), fungicides and disinfectants. Many of these compounds are toxic to aquatic life, although some protection is provided by their low water solubility, slow rate of leaching and dilution. Mortalities in coastal aquaculture have resulted from toxicant leaching from construction materials, and the environmental effects of these toxicants remain largely unresolved. At present , there arefew standards regulating the composition of materials used in aquaculture facilities.

Hormones and growth promoters

An increasing number of hormones and growth promoters are used to alter sex, productive viability and growth of culture organisms. Although many studies have been undertaken to describe their physiological effect in the target organisms, studies of their wider ecological impact have not been undertaken.

Source: GESAMP (Joint Group of Experts on the Scientific Aspects of Marine Pollution), Reducing Environmental Impacts of Coastal Aquaculture. Rep. Stud. GESAMP (47):35p. 1991.

A fisherman brings in a meager harvest of mussels from Dagupan River. Reports about pollution in the area no doubt have an effect on livelihoods like mussel farming.

Source: Phil. Daily Inquirer, Tuesday, January 18, 1995